USES OF CHLORINE AND ITS COMPOUNDS

11.4B - Group 17 (The Halogens)

LEARNING OBJECTIVES

11.2.1.12 know how chlorine water is formed and the reactions of chlorine with aqueous sodium hydroxide

11.2.1.13 understand the use of chlorine as a water treatment and understand the balance of risks and benefits in this process

SUCCESS CRITERIA

- justifies the use of chlorine for water purification (drinking water, pool water)
- considers the formation of substances with chlorinated water and their effect on humans
- considers the advantages and disadvantages of chlorination of water
- considers the harmful effects of unchlorinated water

Disproportionation

- The element chlorine (Cl_2, oxidation number=0) undergoes a type of redox reaction called **disproportionation** when it reacts with alkali.
- Disproportionation can be thought of as a 'self reduction/oxidation' reaction.
- When chlorine reacts with dilute alkali some chlorine atoms are reduced and some are oxidised in the same reaction.
- The actual reaction that takes place depends on the temperature.

- **Chlorine in cold alkali (15 °C)**
  - $Cl_{2(aq)} + 2NaOH_{(aq)} \rightarrow NaCl_{(aq)} + NaClO_{(aq)} + H_2O_{(l)}$

sodium chlorate(I)

- The ionic equation for the reaction is:

$$Cl_{2(aq)} + 2OH^-_{(aq)} \rightarrow Cl^-_{(aq)} + ClO^-_{(aq)} + H_2O_{(l)}$$

0 −1 +1

- oxidation number of Cl
- The ionic equation for this redox reaction can be split into two half-equations, showing the reduction and oxidation.
- The reduction reaction (in which chlorine's oxidation number is reduced is):

$$\tfrac{1}{2}Cl_2 + e^- \rightarrow Cl^-$$

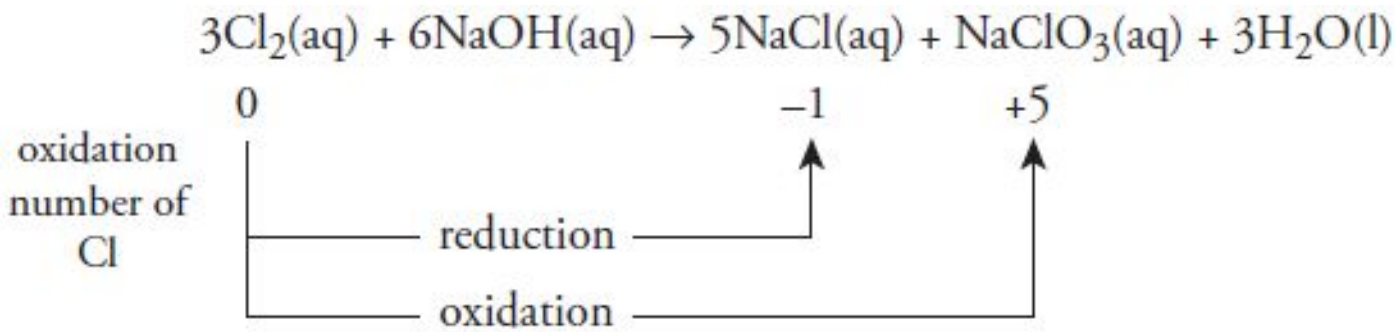
0 −1

- The oxidation reaction is: $\tfrac{1}{2}Cl_2 + 2OH^- \rightarrow ClO^- + H_2O + e^-$

0 +1

Chlorine in hot alkali (70 °C)

- When we add chlorine and hot concentrated aqueous sodium hydroxide a different disproportionation reaction takes place:



USES OF THE HALOGENS AND THEIR COMPOUNDS

Chlorination of water

- Adding a small amount of chlorine to a water supply will kill bacteria and make the water safer to drink.
- The chlorine undergoes disproportionation in water:

$$Cl_{2(aq)} + H_2O_{(l)} \rightarrow HCl_{(aq)} + HClO_{(aq)}$$

0 −1 +1

- HClO is called chloric(I) acid, and it decomposes slowly in solution.
- One theory suggests that it produces reactive oxygen atoms that can kill bacteria in water:

$$HClO \rightarrow HCl + [O]$$

Bleach

- Bleach is an equal mixture of sodium chloride (NaCl) and sodium chlorate(I) (NaClO), made from chlorine and cold alkali.
- It 'bleaches' colours and stains because oxygen atoms from the chlorate(I) ions oxidise dye and other coloured molecules.
- They also kill bacteria when toilets are cleaned with bleach.

The reaction: $Cl_2(aq) + 2NaOH(aq) \longrightarrow NaCl(aq) + NaClO(aq) + H_2O(l)$ is used in industry to produce bleach. The bleaching agent is the chlorate(I) ion.